

What is claimed is:

1. A surgical instrument comprising:
 - a probe assembly providing passage of fluids for irrigating the body interior and for evacuating matter from the body interior;
 - 5 a pump remotely located from the probe assembly for pumping irrigation fluid from a source of the fluid through the probe assembly into the body interior, the pump including a motor connected to a reciprocating drive for actuating a piston to drive the diaphragm;
 - a removable pump cartridge defining a cavity, a one way fluid inlet to the cavity,
 - 10 a one way fluid outlet from the cavity, and a flexible diaphragm for covering the cavity; and
 - a socket defining a through hole through the socket for passage of the piston, the socket and the pump cartridge including cooperating tabs and grooves to engage the pump cartridge with the socket, with the piston positioned in operative engagement with
 - 15 the flexible diaphragm.
2. A surgical instrument as recited in claim 1 further including tubing assembly means for interconnecting the pump cartridge and the irrigation means.
3. A surgical instrument as recited in claim 1 further including handle means for use by an operator in positioning the probe assembly.
- 20 4. An surgical irrigation pump for use with a cartridge cassette having a pumping chamber, the surgical irrigation pump comprising:
 - a pumping actuator;
 - a socket on the pump housing for removably receiving the cartridge cassette to establish working communications between the pumping actuator and the pumping
 - 25 chamber; and
 - a motor in operative engagement with the pump actuator.

5. The surgical irrigation pump of claim 4, wherein the pump pumps irrigation fluid in a pulsed manner.
6. The surgical irrigation pump of claim 4, wherein the cartridge cassette further includes a spring biased poppet valve disposed adjacent the inlet port and a spring
5 biased poppet valve disposed adjacent the outlet port.
7. The surgical irrigation pump of claim 4, further including a first mateable electrical contact disposed in the socket, the cartridge cassette having a cooperating mateable electrical contact disposed to make mated electrical contact with the mateable electrical contact of the socket.
- 10 8. The surgical irrigation pump of claim 7, wherein the first and the second mateable electrical contacts comprise ball and socket connectors.
9. The surgical irrigation pump of claim 4, wherein the cartridge cassette includes a laterally outwardly projecting tab and the socket includes a tab-receiving recess connected with a tab-receiving groove to provide coupling of the cartridge cassette in
15 the socket.
10. A cartridge cassette for use with an surgical irrigation pump having a pumping actuator, the cartridge cassette comprising:
a pumping chamber in fluid communication with a source of fluid and an irrigation conduit;
20 means for removably connecting the cartridge to the surgical irrigation pump to establish working communication with the pumping actuator;
an upstream valve disposed in the cartridge and in fluid communication with the source of fluid and the pumping chamber; and
a downstream valve disposed in the cartridge and in fluid communication with the
25 irrigation conduit and the pumping chamber.

11. The cartridge cassette of claim 10, further including tubing assembly means for interconnecting the cartridge cassette and the source of fluid.
12. The cartridge cassette of claim 10, further wherein the upstream and downstream valves are a spring biased poppet valve disposed adjacent the inlet port and a spring
5 biased poppet valve disposed adjacent the outlet port.
13. The cartridge cassette of claim 10, wherein the means for removably connecting the cartridge cassette to the surgical irrigation pump includes a tab-receiving recess connected with a tab-receiving groove in the cartridge cassette which is adapted to mate with a laterally outwardly projecting tab on the surgical irrigation pump to provide
10 coupling of the cartridge cassette in the surgical irrigation pump.
14. The cartridge cassette of claim 10, wherein the cartridge cassette includes a diaphragm.
15. The cartridge cassette of claim 14, wherein in the mated position of the cartridge cassette in the surgical irrigation pump, the diaphragm is preloaded.
- 15 16. The cartridge cassette of claim 14, wherein the diaphragm has a graduated cross-sectional thickness dimension such that the thickness dimension increases from a central portion of the diaphragm to radially outward portions of the diaphragm.
17. A cartridge cassette for use with an surgical irrigation pump having a pumping actuator, the cartridge cassette comprising:
20 a pumping chamber in fluid communication with a source of fluid and an irrigation conduit;
a tab-receiving groove in the cartridge cassette which is adapted to mate with a laterally outwardly projecting tab on the surgical irrigation pump to provide coupling of the cartridge cassette in the surgical irrigation pump to establish working communication
25 with the pumping actuator;

an upstream valve disposed in the cartridge and in fluid communication with the source of fluid and the pumping chamber; and

a downstream valve disposed in the cartridge and in fluid communication with the irrigation conduit and the pumping chamber.

5 18. The cartridge cassette of claim 17, further including tubing assembly means for interconnecting the cartridge cassette and the source of fluid.

19. The cartridge cassette of claim 17, further wherein the upstream valve is a spring biased poppet valve.

20. The cartridge cassette of claim 17, further wherein the downstream valve is a
10 spring biased poppet valve.

21. The cartridge cassette of claim 17, wherein the cartridge cassette includes a diaphragm.

22. The cartridge cassette of claim 21, wherein in the mated position of the cartridge cassette in the socket, the diaphragm is preloaded.

15 23. The cartridge cassette of claim 21, wherein the diaphragm has a graduated cross-sectional thickness dimension such that the thickness dimension increases from a central portion of the diaphragm to radially outward portions of the diaphragm.

24. A cartridge cassette adapted to mate with a surgical irrigation pump to provide coupling of the cartridge cassette in the surgical irrigation pump to establish working
20 communication with a pumping actuator, the cartridge cassette comprising:

a pumping chamber;

a flexible diaphragm covering the pumping chamber;

an upstream valve disposed in the cartridge adapted for fluid communication with a source of fluid and the pumping chamber; and

a downstream valve disposed in the cartridge adapted for fluid communication with an irrigation conduit and the pumping chamber.

25. The cartridge cassette of claim 24, further including tubing assembly means for interconnecting the cartridge cassette and the source of fluid.

5 26. The cartridge cassette of claim 24, further wherein the upstream valve is a spring biased poppet valve.

27. The cartridge cassette of claim 24, further wherein the downstream valve is a spring biased poppet valve.

10 28. The cartridge cassette of claim 24, wherein in the mated position of the cartridge cassette in the surgical irrigation pump, the diaphragm is preloaded.

29. The cartridge cassette of claim 24, wherein the diaphragm has a graduated cross-sectional thickness dimension such that the thickness dimension increases from a central portion of the diaphragm to radially outward portions of the diaphragm.

15 30. A connector for use in connecting an surgical irrigation pump having a pumping actuator and a cartridge cassette having a pumping chamber, the connector comprising:

a first housing contained with the surgical irrigation pump in juxtaposition to the pumping actuator, the first housing defining first means for allowing removable quick-lock engagement; and

20 a second housing contained with the cartridge cassette in juxtaposition to the pumping chamber, the second housing defining a second cooperating means for allowing removable quick-lock engagement with the first removable quick-lock engagement means;

such that upon connection of the first and second housings, the pumping actuator and the pumping chamber are in working communication.

31. The connector of claim 30, wherein the connector includes a laterally outwardly projecting tab adapted to mate with a tab-receiving groove in the cassette cartridge to provide coupling of the cartridge cassette in the connector.

32. A surgical irrigation apparatus comprising:

5 a first mateable electrical contact disposed in a socket, the first mateable electrical contact adapted to electrically connect to an electronic pump control circuit controlling pumping operations of a pump;

a first fluid conduit adapted to connect a source of irrigation fluid to an inlet port of a cartridge cassette and a second fluid conduit adapted to connect an outlet port
10 of the cartridge cassette to an inlet port of a suction/irrigation probe;

the cartridge cassette having a configuration such that it is releasably received in the socket;

the cartridge cassette having a cooperating mateable electrical contact disposed to make mated electrical contact with the mateable electrical contact of the socket when
15 the cartridge cassette is in the socket; and

the cooperating mateable electrical contact adapted to electrically connect to a switch operatively associated with the suction/irrigation probe, the switch being in electronic communication with the pump.

33. The surgical irrigation apparatus of claim 32, wherein the switch is a
20 depressible key actuator on a trumpet valve.

34. The surgical irrigation apparatus of claim 32, wherein the pump pumps irrigation fluid in a pulsed manner.

35. The surgical irrigation apparatus of claim 32, wherein the cartridge cassette further includes a spring biased poppet valve disposed adjacent the inlet port and a
25 spring biased poppet valve disposed adjacent the outlet port.

36. The surgical irrigation apparatus of claim 32, wherein the first and the second mateable electrical contacts comprise ball and socket connectors.
37. The surgical irrigation apparatus of claim 32, wherein the socket includes a laterally outwardly projecting tab and the cartridge cassette includes a tab-receiving
5 groove to provide coupling of the cartridge cassette in the socket.
38. The surgical irrigation apparatus of claim 32, wherein the cartridge cassette includes a diaphragm.
39. The surgical irrigation apparatus of claim 38, wherein in the mated and locked position of the cartridge cassette in the socket, the diaphragm and presses is preloaded.
- 10 40. The surgical irrigation apparatus of claim 38, wherein the diaphragm has a graduated cross-sectional thickness dimension such that the thickness dimension increases from a central portion of the diaphragm to radially outward portions of the diaphragm.
41. The surgical irrigation apparatus of claim 32, wherein the suction/irrigation
15 probe further comprises a trumpet valve having a switch contact disposed adjacent a depressable key actuator, a switch actuator mounted on the depressable key actuator and positioned to electrically contact the switch contact when the depressable key actuator is moved to a depressed position.
42. The surgical irrigation apparatus of claim 32, wherein the electronic pump
20 control circuit includes an electronics controller including a pulse generator that generates pulses, with the duty cycle of the pulses controlling the speed of the motor; and a trumpet valve switch interface in electronic connection to a switch, the interface providing a signal to the controller.
43. An electronic pump control circuit comprising:

an electronics controller including a pulse generator, the pulse generator generating pulses, the duty cycle of the pulses controlling the speed of the motor; and a trumpet valve switch interface in electronic connection to a switch, the interface providing a signal to the controller.

5 44. The control circuitry of claim 43 further including a current sensor in the motor drive circuit, the sensed motor drive current being controller summed with the speed signal of the controller to create a variation in the speed set value in proportion to the current being sensed through the motor.

45. The control circuitry of claim 44 wherein the controller includes a pulse width
10 modulator.

46. The control circuitry of claim 45 wherein the pulse width modulator includes a pulse width modulation oscillator, a second pulse width modulation oscillator that modulates the pulses generated by the first pulse width modulator oscillator, and a transistor that receives the modulated pulses from the second pulse width modulator
15 oscillator.

47. The control circuitry of claim 45 wherein the pulse width modulator compares the voltage output from the controller to the instantaneous voltage of the linear-ramp sawtooth voltage, and turns off power to the motor any time that the linear-ramp sawtooth voltage is higher than the controller, until the start of the next pulse cycle.

20 48. A diaphragm for use in a cassette having a pump chamber and a surgical irrigation pump having a pumping actuator, the diaphragm comprising:

an inner portion that faces the pump chamber of the cassette;

an outer portion that interacts with the pumping actuator; and

means to follow the piston while improving the return stroke.

25 49. The diaphragm of claim 48 further wherein the means to follow the piston while improving the return stroke includes a graduated cross-sectional thickness dimension of

the diaphragm such that the thickness dimension increases from a central portion of the diaphragm to radially outward portions of the diaphragm.

50. The diaphragm of claim 49 further wherein the diaphragm acts like a hinge.
51. The diaphragm of claim 49 further wherein the diaphragm acts like a cantilever.
- 5 52. The diaphragm of claim 48 further wherein the means to follow the piston while improving the return stroke includes a cup-like portion defined on the diaphragm, the cup designed to interact with the piston.
53. The diaphragm of claim 52 further wherein the radius of the cup is smaller than that of the piston, thereby creating a suction cup like mechanism.
- 10 54. The diaphragm of claim 48 further wherein the means to follow the piston while improving the return stroke includes a dome defined on the diaphragm, the dome protruding in opposite direction to pump piston.
55. The diaphragm of claim 48 further wherein the diaphragm defines a downwardly extending portion on the outer periphery.
- 15 56. The diaphragm of claim 55 further wherein the downwardly extending portion defines a series of ridges that act to secure and seal the diaphragm into a fluid type engagement.
57. The diaphragm of claim 48 further wherein an outside of an outer periphery of the diaphragm 93 defines an outwardly extending bulb portion.